

CLAIMS:

1. A communication network control method for a communication network including a hub and a plurality of user nodes, said method comprising steps of:

transmitting a sequence of frames from the hub to the plurality of user nodes at
5 a fixed frame rate F , each frame in the sequence of frames including a respective burst time plan;

transmitting a respective data burst in a frame time period from each of the user nodes to the hub after receiving each burst time plan in the sequence of frames from the hub, the respective data burst from each of the user nodes being delayed by a
10 respective remote delay R_{fsdn} for each of the user nodes, and the respective data burst from each of the user nodes including data in at least one time slot of the frame time period according to the respective burst time plan in the sequence of frames from the hub,

wherein each data burst from each of the user nodes is received at the hub
15 such that the start of the frame time period for each data burst occurs simultaneously at the hub, and the start of the frame time period for each data burst occurs a hub delay H_{fsd} after a start of a frame in a predetermined frame in the sequence of frames from the hub.

20 2. The method of claim 1, further comprising steps of:

calculating the hub delay H_{fsd} ; and

transmitting the hub delay H_{fsd} , a ground delay t_{gd} , the fixed frame rate F , a location of the satellite, and a location of the hub from the hub to a respective user node.

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3. The method of claim 2, further comprising a step of:
calculating the remote delay R_{fsdn} for each user node.

4. The method of claim 3, wherein the step of calculating the hub delay H_{fsd}
5 further comprises a step of:
calculating a signal propagation delay between the hub and the satellite t_{hs}
from the location of the satellite and the location of the hub.

5. The method of claim 4, wherein the step of calculating the hub delay H_{fsd}
10 further comprises a step of:
calculating the hub delay H_{fsd} based on the ground delay t_{gd} , the fixed frame
rate F , the signal propagation delay between the hub and the satellite t_{hs} , a signal
propagation delay between the satellite and a location on the surface of the earth
approximately under the satellite t_{svr} , and a maximum satellite tracking error caused
15 by a movement of the satellite between a position at a center of an extent of the
satellite motion and a position at a closest approach of the satellite to earth k ,
wherein $H_{fsd} = \text{mod}[(2t_{hs} + 2t_{svr} + t_{gd} + 1/F - k), 1/F]$.

6. The method of claim 3, wherein the step of calculating the remote delay
20 R_{fsdn} for each user node further comprises a step of:
calculating a signal propagation delay between the satellite and the respective
user node t_{sm} from the location of the satellite and the location of the respective user
node.

7. The method of claim 6, wherein the step of calculating the remote delay R_{fsdn} for each user node further comprises a step of:

calculating the remote delay R_{fsdn} for each user node based on the hub delay H_{fsd} , a ground delay t_{gd} , the fixed frame rate F , the signal propagation delay between
5 the hub and the satellite t_{hs} , and the signal propagation delay between the satellite and a respective user node t_{sm} ,

wherein $R_{fsdn} = 1/F - \text{mod}[(2t_{hs} + 2t_{sm} + t_{gd} - H_{fsd}), 1/F]$.

8. A wireless communication network comprising:

10 a hub; and

a plurality of user nodes configured to communicate via a satellite with said hub, wherein

said hub is configured to transmit a sequence of frames to the plurality of user nodes at a fixed frame rate F , each frame in the sequence of frames including a
15 respective burst time plan,

each of said plurality of user nodes being configured to transmit a respective data burst in a frame time period to the hub after receiving each burst time plan in the sequence of frames from the hub, the respective data burst from each of the user nodes being delayed by a respective remote delay R_{fsdn} for each of the user nodes, and
20 the respective data burst from each of the user nodes including data in at least one time slot of the frame time period according to the respective burst time plan in the sequence of frames from the hub, and

each data burst from each of the user nodes is received at the hub such that the start of the frame time period for each data burst occurs simultaneously at the hub,
25 and the start of the frame time period for each data burst occurs a hub delay H_{fsd} after

a start of a frame in a predetermined frame in the sequence of frames from the hub.

9. The network of claim 8, wherein:

said hub is configured to calculate the hub delay H_{fsd} and transmit the hub
5 delay H_{fsd} , a ground delay t_{gd} , the fixed frame rate F , a location of the satellite, and a
location of the hub to a respective user node.

10. The network of claim 8, wherein:

at least one of said hub and said plurality of user nodes is configured to
10 calculate the remote delay R_{fsdn} for each user node.

11. The network of claim 10, wherein:

said at least one of said hub and said plurality of user nodes is configured to
calculate a signal propagation delay between the hub and the satellite t_{hs} from the
15 location of the satellite and the location of the hub.

12. The network of claim 11, wherein:

said hub is configured to calculate the hub delay H_{fsd} based on the ground
delay t_{gd} , the fixed frame rate F , the signal propagation delay between the hub and the
20 satellite t_{hs} , a signal propagation delay between the satellite and a location on the
surface of the earth approximately under the satellite t_{svr} , and a maximum satellite
tracking error caused by a movement of the satellite between a position at a center of
an extent of the satellite motion and a position at a closest approach of the satellite to
earth k ,

wherein $H_{fsd} = \text{mod}[(2t_{hs} + 2t_{svr} + t_{gd} + 1/F - k), 1/F]$.

13. The network of claim 12, wherein:

said at least one of said hub and said plurality of user nodes is configured to
5 calculate a signal propagation delay between the satellite and the respective user node
 t_{sm} from the location of the satellite and the location of the respective user node.

14. The network of claim 13, wherein:

said at least one of said hub and said plurality of user nodes is configured to
10 calculate the remote delay R_{fsdn} for each user node based on the hub delay H_{fsd} , a
ground delay t_{gd} , the fixed frame rate F , the signal propagation delay between the hub
and the satellite t_{hs} , and the signal propagation delay between the satellite and a
respective user node t_{sm} ,

wherein $R_{fsdn} = 1/F - \text{mod}[(2t_{hs} + 2t_{sm} + t_{gd} - H_{fsd}), 1/F]$.

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15. A hub for a wireless communication network, said wireless
communications network including the hub, a plurality of user nodes and a satellite,
comprising:

a processor configured to form a sequence of frames, each frame in the
20 sequence of frames including a respective burst time plan;

a transmitter configured to transmit the sequence of frames via the satellite to
the plurality of user nodes at a fixed frame rate F ;

a receiver configured to receive a respective data burst in a frame time period,
said respective data burst being transmitted from the plurality of user nodes after
25 receiving each burst time plan in the sequence of frames, the respective data burst

from each of the user nodes being delayed by a respective remote delay R_{fsdn} for each of the user nodes, and the respective data burst from each of the user nodes including data in at least one time slot of the frame time period according to the respective burst time plan in the sequence of frames from the hub, wherein

5 each data burst from each of the user nodes is received at the hub such that the start of the frame time period for each data burst occurs simultaneously at the hub, and the start of the frame time period for each data burst occurs a hub delay H_{fsd} after a start of a frame in a predetermined frame in the sequence of frames from the hub.

10 16. The hub of claim 15, wherein:

 said processor is configured to calculate the hub delay H_{fsd} and transmit the hub delay H_{fsd} , a ground delay t_{gd} , the fixed frame rate F , a location of the satellite, and a location of the hub to a respective user node.

15 17. The hub of claim 15, wherein:

 said processor is configured to calculate the remote delay R_{fsdn} for each user node.

 18. The hub of claim 17, wherein:

20 said hub is configured to calculate a signal propagation delay between the hub and the satellite t_{hs} from the location of the satellite and the location of the hub.

 19. The hub of claim 18, wherein:

 said processor is configured to calculate the hub delay H_{fsd} based on the
25 ground delay t_{gd} , the fixed frame rate F , the signal propagation delay between the hub

and the satellite t_{hs} , a signal propagation delay between the satellite and a location on the surface of the earth approximately under the satellite t_{svr} , and a maximum satellite tracking error caused by a movement of the satellite between a position at a center of an extent of the satellite motion and a position at a closest approach of the satellite to earth k,

wherein $H_{fsd} = \text{mod}[(2t_{hs} + 2t_{svr} + t_{gd} + 1/F - k), 1/F]$.

20. The hub of claim 19, wherein:

said processor is configured to calculate a signal propagation delay between the satellite and the respective user node t_{sm} from the location of the satellite and the location of the respective user node.

21. The hub of claim 20, wherein:

said processor is configured to calculate the remote delay R_{fsdn} for each user node based on the hub delay H_{fsd} , a ground delay t_{gd} , the fixed frame rate F , the signal propagation delay between the hub and the satellite t_{hs} , and the signal propagation delay between the satellite and a respective user node t_{sm} ,
wherein $R_{fsdn} = 1/F - \text{mod}[(2t_{hs} + 2t_{sm} + t_{gd} - H_{fsd}), 1/F]$.

22. A hub for a wireless communication network, said wireless communications network including the hub, a plurality of user nodes and a satellite, comprising:

means for transmitting a sequence of frames from the hub to the plurality of user nodes at a fixed frame rate F , each frame in the sequence of frames including a respective burst time plan; and

means for receiving a respective data burst in a frame time period from each of the user nodes after the user nodes have received each burst time plan in the sequence of frames from the hub, the respective data burst from each of the user nodes being delayed by a respective remote delay R_{fsdn} for each of the user nodes, and the

5 respective data burst from each of the user nodes including data in at least one time slot of the frame time period according to the respective burst time plan in the sequence of frames from the hub,

wherein each data burst from each of the user nodes is received at the hub such that the start of the frame time period for each data burst occurs simultaneously

10 at the hub, and the start of the frame time period for each data burst occurs a hub delay H_{fsd} after a start of a frame in a predetermined frame in the sequence of frames from the hub.

23. A user node in a plurality of user nodes for a wireless communication

15 network, said wireless communications network including the hub, the plurality of user nodes and a satellite, said user node comprising:

means for receiving from the hub a sequence of frames at a fixed frame rate F , each frame in the sequence of frames including a respective burst time plan;

means for transmitting a data burst in a frame time period from the user nodes

20 to the hub after receiving each burst time plan in the sequence of frames from the hub, the respective data burst from the plurality of user nodes being delayed by a respective remote delay R_{fsdn} , and the respective data burst from each of the user nodes including data in at least one time slot of the frame time period according to the respective burst time plan in the sequence of frames from the hub,

wherein each data burst from each of the user nodes is received at the hub such that the start of the frame time period for each data burst occurs simultaneously at the hub, and the start of the frame time period for each data burst occurs a hub delay H_{fsd} after a start of a frame in a predetermined frame in the sequence of frames

5 from the hub.